Spatial Correlation of Fluid Particle Acceleration in High Reynolds Number Turbulent Flows

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Our understanding of the role of pressure in turbulence is limited because of the extreme difficulty of measuring directly the instantaneous pressure field in a turbulent flow. In high Reynolds number flows, indirect information about pressure can be obtained from measurements of fluid particle accelerations, which differ from the pressure gradient only by a vanishingly small viscous term. As an example, Obukhov and Yaglom [1, 2] predicted the acceleration correlation functions by relating them to the correlation of pressure fluctuations.

In recent years, the Lagrangian accelerations of fluid particles in intense turbulent flows have been accessible to experiments using optical Lagrangian Particle Tracking (LPT) [3, 4]. Previous measurements were, however, limited to single particle statistics due to the one-dimensional nature of the silicon-strip detectors. More recently, the use of high-speed digital cameras in LPT has allowed us to follow multiple particles simultaneously with a temporal resolution sufficient to measure acceleration [5]. Here we report measurements of acceleration correlations in intense turbulence generated between counter-rotating baffled disks in water. The Taylor micro-scale Reynolds number R_λ ranges from 200 to 700. As shown in Figure , the measured correlation functions, both longitudinal and transverse, agree well with the predictions by Obukhov and Yaglom.

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References

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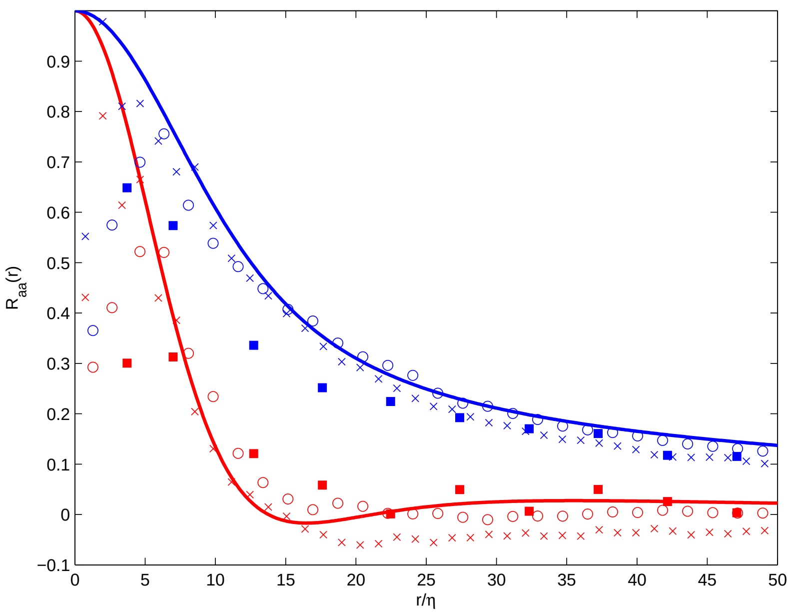

Figure 1: Comparison of the measured acceleration correlation functions with the Obukhov-Yaglom prediction [1]. The red and blue lines are the predicted longitudinal and transverse correlation functions, respectively. The symbols are corresponding measurements from LPT data at different Reynolds numbers: crosses – $R_\lambda = 200$, circles – $R_\lambda = 350$, and filled squares – $R_\lambda = 690$.

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